RESOURCE RECOVERY FROM SOLID WASTE

Mark Luttner
and
Fred Hitzhusen

ESO 293

Department of Agricultural Economics and Rural Sociology
The Ohio State University
Columbus, Ohio

October, 1975

POTENTIAL FOR RESOURCE RECOVERY FROM SOLID WASTE: SOME IMPLICATIONS FOR NON-METROPOLITAN OHIO

Mark Luttner and Fred Hitzhusen*

The energy crisis has accentuated a problem facing industry and agriculture in Ohio and the rest of the U. S. for many years--that of the increasing scarcity and cost of fossil fuels. In meeting the energy crisis, new sources of energy are being developed (nuclear, solar) and traditional sources (coal, oil, natural gas) expanded, but one readily available, low-cost source in excess supply has largely been overlooked. That source of energy goes by many names--trash, refuse, garbage, solid waste--but by any name, it represents a potentially significant energy source. For example, the energy lost each day by discarding solid wastes from residential, commercial, industrial, agricultural, and forestry operations in 1971 contained the energy value equivalent to 2.5 million barrels of oil (6). One source has estimated that refuse-derived energy can supply up to 10% of total U. S. energy requirements (13). Farsighted planning on the part of municipal, county, and state administrators may turn a present day liability into a future asset through development of solid waste resource recovery projects.

The Solid Waste Dilemma

Present methods of solid waste disposal are increasingly coming under criticism as health nuisances and environmental degraders. The traditional alternatives in waste disposal, particularly landfilling and incineration, contribute to a number of environmental problems. Incinerators release

*Graduate Research Associate and Assistant Professor, respectively, Resource Economics, Department of Agricultural Economics and Rural Sociology, Ohio State University.

millions of tons of carbon monoxide, particulates, nitrogen oxides, sulfur oxide and hydrocarbons into the atmosphere each year (1). Landfills are problematic in that they release leachate (a liquid pollutant) into streams and groundwater supplies, emit methane and carbon dioxide, provide breeding areas for insect and animal pests, and are susceptible to problems of combustion. Many documented cases of pollution of drinking water sources (particularly wells) by landfill leachate have occurred, most of which result in the affected individual, municipality, or firm installing an expensive alternative source of water supply (15). Air pollution from incinerators damages vegetation, corrodes structures, and creates respiratory health hazards to humans and animals (2,8).

In controlling health and environmental problems created by the traditional methods of waste disposal, officials must contend with increasingly higher disposal costs, public resistance to landfills, a lack of suitable landfill sites, and a lack of fuel needed to operate incinerators. For many communities, an alternative to the current solid waste disposal practices is needed.

Resource Recovery Defined

The term "resource recovery" may refer to any of a number of concepts, including recycling, reusing, or reprocessing. More specifically, resource recovery includes:

1) Reusing objects in their original form, such as glass containers.
2) Recovering materials from solid waste suitable for use as raw materials in the production of other goods, e.g., metals, paper, glass, etc.

3) Recovering materials which are not suitable for use as a raw material input, but which may serve a secondary purpose, e.g., using crushed glass as a base for paving material.
4) Reprocessing portions of the solid waste mass into new products, such as compost, or converting it into chemicals such as hydrochloric acid.
5) Converting solid waste into a solid or liquid fuel for the production of energy (9).

Energy recovery from solid waste has long been practiced in many European countries. Solid waste management systems in Germany, Holland, Denmark, France, and other nations use refuse principally as a fuel to produce steam, which is forced under pressure to drive electricity-generating turbines. By the end of 1975, Germany will serve 25% of its total population by burning their refuse in steam heat recovery systems. Until recently, however, the incentives which would enable energy recovery from waste in the United States did not exist. The energy crisis has provided the economic incentive by raising the relative price of traditional fossil fuels, and American manufacturers have responded to the technology gap by developing a wide variety of refuse recovery systems. The six general energy recovery methods which utilize solid waste include:

1) Burning refuse in steam-generating incinerators. This alternative produces steam used for heating or cooling buildings, industrial process use, or for powering electricity-generating turbines.
2) Burning refuse in heat exchangers. This process utilizes solid waste as a supplementary fuel (in addition to coal, oil, or natural gas) to produce steam for driving electricity turbines.

3) Pyrolysis. Pyrolyzing solid waste involves heating the refuse in the absence of oxygen to break down the material into oils, gases. and residue. Pyrolysis oil is quite suitable for use in oil-fired boilers.

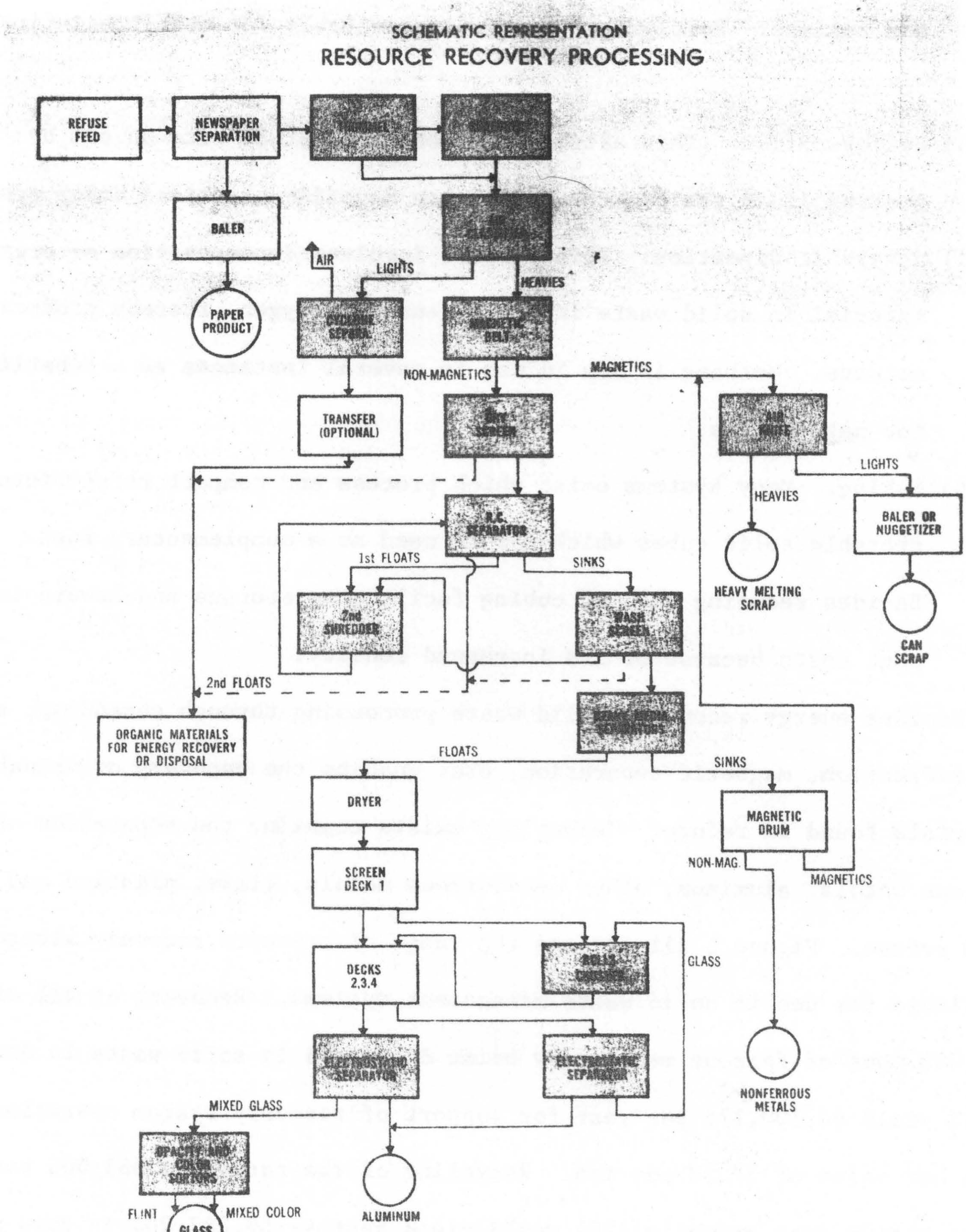
4) Hydrogenation. This alternative converts refuse into an oil by heating it in the presence of carbon monoxide and steam under pressure.

5) Anaerobic Digestion. This process involves decomposition of organic material in solid waste in the absence of oxygen, thereby producing methane. Methane is now in use in several instances as a substitute for natural gas.

6) Cubing. Many systems exist which process and compact refuse into storable solid cubes which may be used as a supplementary fuel. Besides reducing volume, cubing facilitates storage and lowers transport costs because of its increased density.

Besides energy recovery, solid waste processing through shredding, air classification, magnetic separation, etc. enables the recovery of valuable materials found in refuse. Technology exists enabling the separation of ferrous metals, aluminum, other non-ferrous metals, glass, plastics and paper from refuse. Figure 1 illustrates the range of resource recovery alternatives available for use in solid waste management systems. Recovery of all of the 547,000 tons of ferrous metals now being discarded in solid waste in Ohio (10) would yield $4,100,775 per year for support of recovery system operations at a net value of $7.50 per ton. Recycling of the estimated 663,000 tons of glass thrown away annually (10) would yield another $9,282,000 in Ohio alone based on a net value of $14 per ton for separated glass cullet. In addition, by reusing glass, metals, and other material, a significant amount of energy

FIGURE 1. SOLID WASTE RESOURCE RECOVERY ALTERNATIVES



will be saved which would otherwise have gone into the mining, smelting, processing and transportation of virgin raw material. Material recovery thereby provides a double incentive for consideration in solid waste management.

Resource Recovery in Ohio

Materials recovery is actively being practiced in Franklin, Ohio, which operates a $3.2 million plant that processes approximately 50 tons of refuse per day. The plant, financed largely by the Federal Environmental Protection Agency, recovers paper fibers, ferrous and aluminum metals, and color-sorted glass. Its net operating costs of $6 per ton of refuse processed make the system reasonably competitive with a well-managed landfill operation.

Energy recovery from solid waste is now being studied and implemented in several Ohio metropolitan areas. Akron is developing a system which will burn refuse in order to produce steam for industrial purposes. Columbus now processes all of its refuse in an advanced system of three transfer stations; in the stations, refuse is shredded and ferrous metals removed magnetically. The shredded refuse is presently landfilled, but plans call for the construction of a new municipal electric generating plant fueled almost exclusively by the prepared refuse. The ferrous metal recovered at the facilities is sold to a scrap dealer for reuse, with the revenues helping to offset the system's costs.

In non-metropolitan Ohio, potential resource recovery projects have not been adequately investigated to indicate general feasibility. An exception to this is a study underway in the city of Orrville (population 7,408) to determine the feasibility of utilizing prepared refuse as a supplementary fuel in the boilers of the city-owned electric power plant. Orrville Municipal Power serves approximately 5,400 customers in and around the Orrville area, and is fairly representative of a number of non-metropolitan electric utilities in terms of size, generating capacity, operation, etc. Preliminary research has indicated that 20 to 30 percent of the coal now being burned (about 300 tons per day) in the utility's two pulverized-coal boilers could be replaced by prepared refuse. Replacing 20 percent of the coal with refuse would require processing of approximately 197 tons of raw refuse per day to yield the needed 138 tons of combustible prepared refuse (solid waste is only about 70 percent combustible and contains approximately 5,000 BTU's per pound, as compared to 11,500 BTU's per pound of coal).

The recovery system, located adjacent to the electric plant, could receive refuse by packer truck or transfer trailer. After weigh-in, the refuse would be shredded, air classified (to separate combustibles from non-combustibles), ferrous metals would be magnetically separated, and the combustible refuse stored prior to pneumatic injection into the boilers as needed. Non-combustibles would be taken to a landfill area for disposal. Figure 2 diagrams the general process used in refuse processing facilities of this type. By utilizing a 20:80 refuse to coal firing ratio, the recovery facility will handle approximately 72 percent of the total of 280 tons of refuse generated daily in Wayne County.

Besides drastically reducing the landfill requirements due to firing the combustible refuse and recovering the ferrous metal content, the proposed system may reduce the problems of water contamination by landfill leachate, reduce the incidence of animal and insect pests, provide an environmentally acceptable method of waste disposal, and reduce the operating costs of the facility due to the reduced need for its number one operating expense item--coal. By lowering production costs, the utilization of refuse as fuel

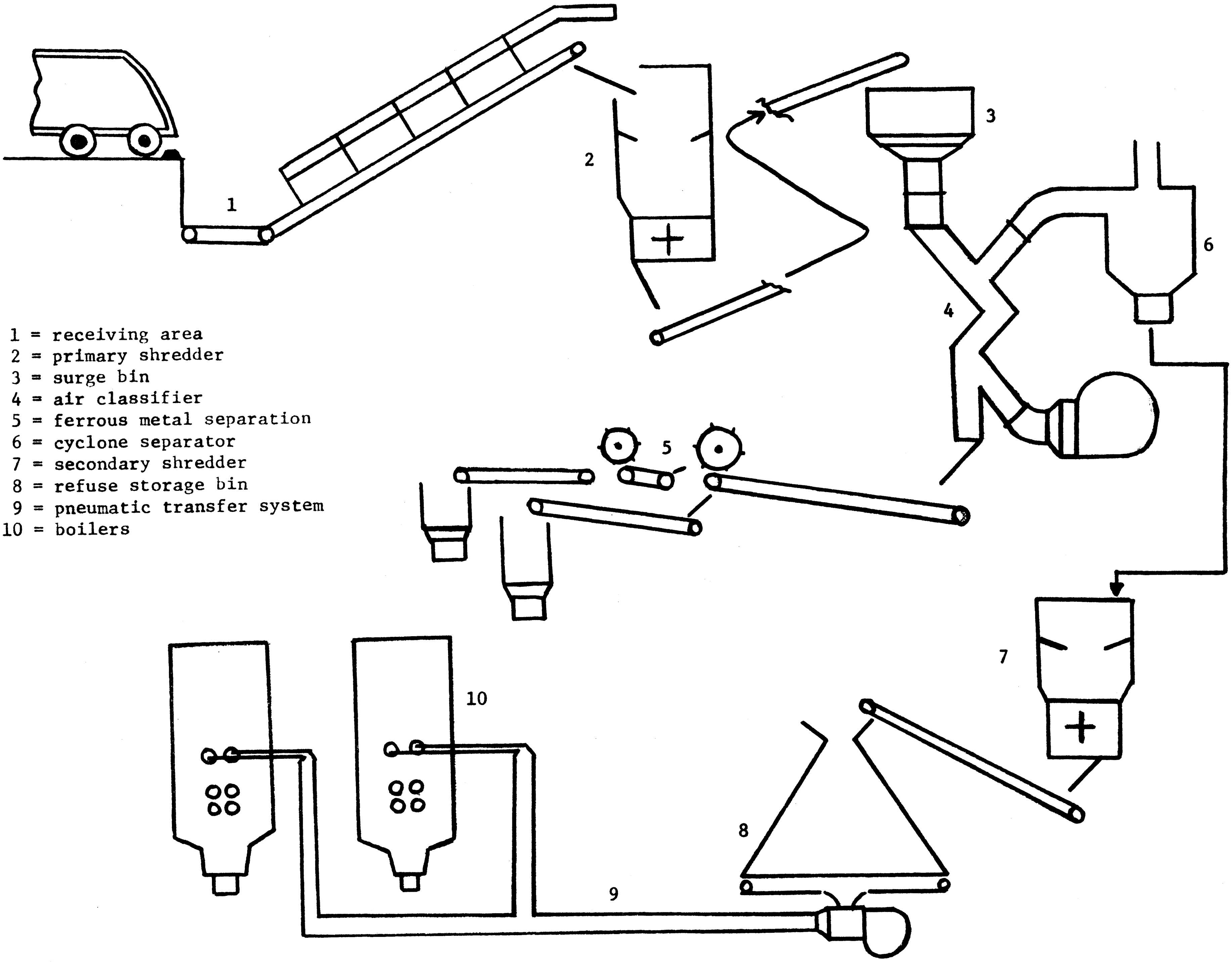


Figure 2

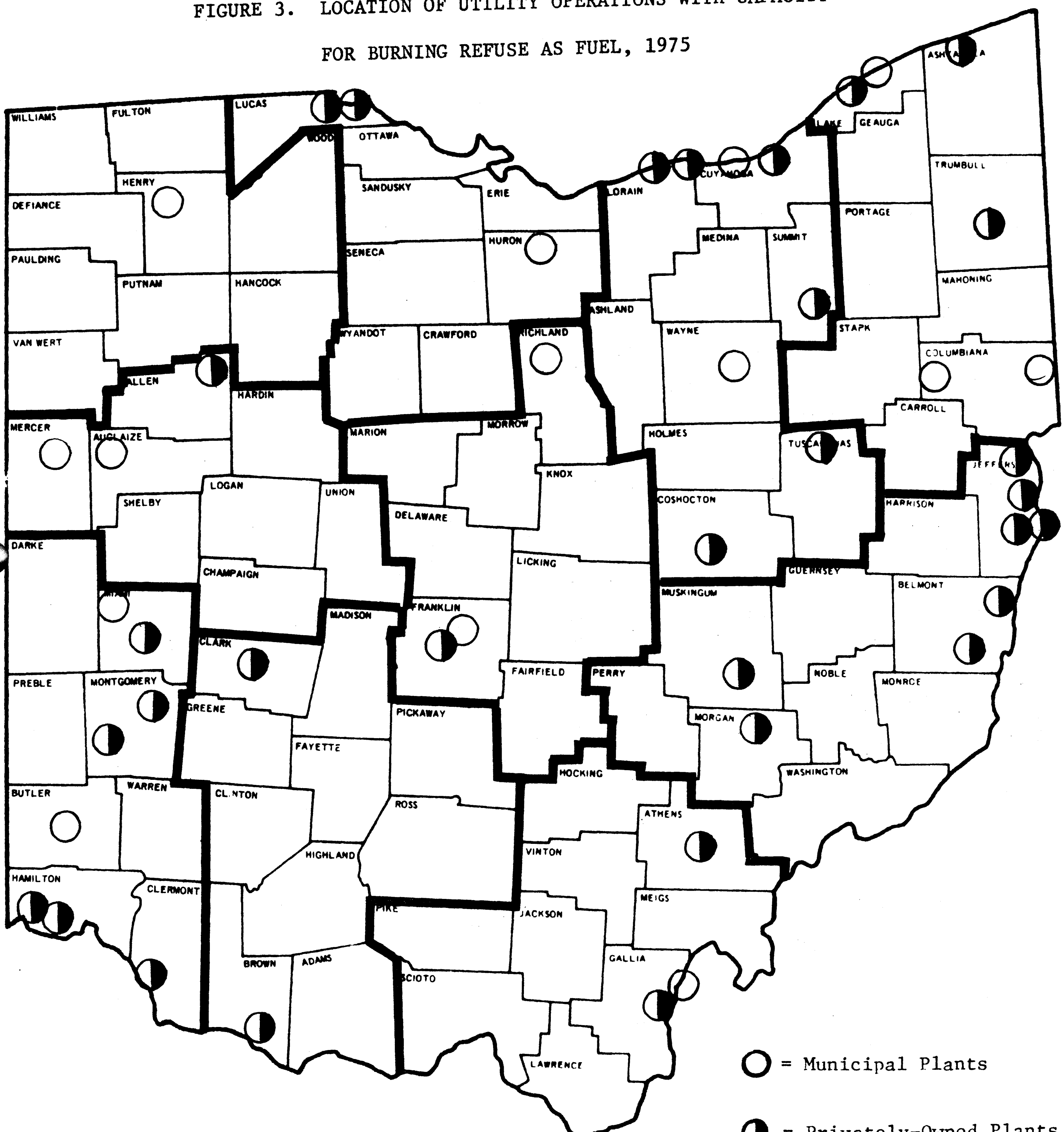
Shematic Diagram of Orrville Municipal Power Recovery System may permit reduction of electric rates to residential, commercial, agricultural and industrial customers of Orrville Municipal Power. The chief obstacle to the development of the facility (as with most other recovery projects), is its anticipated capital requirement of about $3.1 million. However, the technique is a proven one (similar systems are now operating in St. Louis, Missouri and Ames, Iowa) and the potential benefits are significant.

Extensions and Implications for Ohio

Research has indicated that energy recovery systems such as those being developed in Akron and Orrville may be suitable for many more locations in Ohio and elsewhere. One study (12) has indicated the presence of 45 privately and publically owned steam-electric boiler facilities in Ohio which have the capacity to burn refuse as a supplementary fuel. Figure 3 shows the location of these potential energy recovery facilities. The key factors determining suitability of these plants to energy recovery include the nature and amounts of refuse available, plant location with respect to size of refuse generation areas and landfills, and suitability of boilers to accommodate refuse as fuel. Of these plants, over half are located in non-metropolitan counties of the state. These non-metropolitan counties could provide an estimated 3,500 tons of refuse per day to be used in energy and material recovery systems. Other non-metropolitan counties located adjacent to those in which electric utilities are located may also find it economically feasible to supply refuse for burning if the utilities have the required fuel capacity.

Table 1 estimates the potential coal savings from energy recovery in the non-metropolitan and metropolitan counties of Ohio. This economic incentive for utilizing prepared refuse as an electricity-producing fuel in utility boilers combined with potential revenues from recovered materials,

FIGURE 3. LOCATION OF UTILITY OPERATIONS WITH CAPACITY FOR BURNING REFUSE AS FUEL, 1975



SOURCE: (12), p. 219.

reduced landfill requirements, etc., would appear to offer considerable economic potential. However, the data in Table 1 require some additional explanation. The per capita refuse generation estimate of 3.5 pounds per day may be considered one of two ways: 1) As a conservative refuse estimate for all solid waste generated (residential, commercial, institutional and industrial) or, 2) As an average for waste generated and available for burning as fuel, not including industrial waste. This second approach is useful because it recognizes that industrial waste is often handled in a much different manner than that from other sources because of its particular characteristics based on industry type. Table 1 also indicates refuse amounts potentially available for use as fuel; whether or not these quantities could be utilized depends upon the fuel-burning capacity of the plants in question. More precise estimates of the volume and type of waste generated, the suitability of the plants to accommodate the waste generated and the economic feasibility of doing so are subjects that merit additional study.

Resource recovery from solid waste is not a panacea for the energy and raw materials problems which Ohio and the country are experiencing. As indicated earlier, the energy recovered from solid waste could supply at most 10% of the nation's energy needs. In addition, capital requirements for recovery facilities are high. Thus, growth in this area particularly in smaller communities, will probably be moderate without state or Federal assistance. However, as the costs of fossil fuels rise, as suitable landfill sites become more scarce, as environmental regulations concerning waste disposal become more rigid, and as the demand for electrical energy grows, the economic feasibility of resource recovery systems will continue to improve. By making farsighted commitments to energy development, resource conservation and

TABLE 1

POTENTIAL COAL SAVINGS FROM RESOURCE RECOVERY IN OHIO COUNTIES CONTAINING ELECTRIC UTILITIES WITH REFUSE-BURNING CAPACITY

County	Population[1]	Tons of Waste Generated/Day[2]	Maximum Tons Coal Replaceable/Day[3]	Est. Coal Savings/Day[4]	Est. Coal Savings/Year[5]
Non-Metropolitan:					
Allen	111,144	194.5	59.2	$ 1,184	$ 367,011
Ashtabula	98,237	171.9	52.3	1,046	324,366
Athens	54,889	96.1	29.2	585	181,335
Auglaize	38,602	67.6	20.6	411	127,557
Belmont	80,917	141.6	43.1	862	267,191
Butler	226,207	395.9	120.5	2,410	747,042
Clark	157,115	275.0	83.7	1,674	518,910
Clermont	95,725	167.5	51.0	1,020	316,076
Columbiana	108,310	189.5	57.7	1,154	357,678
Coshocton	33,486	58.6	17.8	357	110,546
Gallia	25,239	44.2	13.4	269	83,328
Henry	27,058	47.4	14.4	288	89,342
Huron	49,587	86.8	26.4	528	163,742
Jefferson	96,193	168.3	51.2	1,025	317,626
Lake	197,200	345.1	105.3	2,101	651,186
Mercer	35,265	61.7	18.8	376	116,436
Miami	84,342	147.6	44.9	898	278,504
Morgan	12,375	21.7	6.6	132	40,858
Muskingum	77,826	136.2	41.5	829	256,990
Richland	129,997	227.5	69.2	1,385	429,226
Tuscarawas	77,211	135.1	41.1	822	254,944
Wayne	87,123	152.5	46.4	928	287,759
Non-Metro. TOTAL	1,904,058	3,332.1	1,014.1	$20,282	$6,287,482
Metropolitan:					
Cuyahoga	1,721,300	3,012.3	916.7	$18,336	$5,684,036
Franklin	833,249	1,458.2	443.7	8,876	2,751,498
Hamilton	924,018	1,617.0	492.1	9,842	3,051,020
Lucas	484,370	847.7	258.0	5,160	1,599,476
Lorain	256,843	449.5	136.8	2,736	848,160
Mahoning	303,424	531.0	161.6	3,232	1,001,920
Montgomery	606,148	1,060.8	322.8	6,457	2,001,608
Metro. TOTAL	5,129,352	8,976.4	2,731.9	$54,638	$16,937,904
GRAND TOTAL	7,033,410	12,308.5	3,746.0	$74,920	$23,225,386

[1] 1973 figures.

[2] Average generation of 3.5 lbs./capita/day.

[3] Assumes waste 70% combustible and contains 5,000 BTU/LB; coal 11,500 BTU/LB.

[4] Average coal price of $20/ton delivered.

[5] 310 operating days/year for recovery facility.

environmental protection through resource recovery systems, Ohioans can help resolve the dual problems of energy and solid waste management.

BIBLIOGRAPHY

1. Baum, Bernard and Parker, Charles. Solid Waste Disposal, Volume 1: Incineration and Landfill, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, 1973, p. 108.

2. Darley, Ellis F. "Vegetation Damage From Air Pollution," in Combustion-Generated Air Pollution, Ernest S. Starkman, Editor., Plenum Press, New York, 1971, p. 247.

3. Freeman, Ralph S. "Turning Refuse Into Boiler Fuel," 1975 Generation Handbook: Chemical Engineering.

4. Horner and Shifrin, Inc. Solid Waste As Fuel For Power Plants, National Technical Information Service, Springfield, Virginia, 1973.

5. Huie, John M. Solid Waste Management. Cooperative Extension Service, Purdue University, Lafayette, Indiana.

6. Levy, Steven J. Markets and Technology For Recovering Energy From Solid Waste, U. S. Environmental Protection Agency, Publication SW-130, 1974, p.1.

7. Lowe, Robert A. Energy Recovery From Waste, U. S. Environmental Protection Agency Publication SW-36, d.ii, 1973.

8. Nadel, Jay A. "Effects of Air Pollution on Health," in Combustion-Generated Air Pollution, Ernest S. Starkman, Editor, Plenum Press, New York, 1971, p. 241.

9. National Center For Resource Recovery, Resource Recovery From Municipal Solid Waste, D. C. Health and Co., Lexington, Massachusetts, 1974.

10. Schulz, Robert L. "Waste Disposal: The Connecticut Approach," Ohio Cities and Villages, February 1974, p. 25.

11. Stoker, H. S. and Seager, S. L. Environmental Chemistry: Air and Water Pollution, Scott, Foresman and Co., Glenview, Illinois, 1972.

12. Tunnah, B. G., Hakki, Adel, and Leonard Roger J., Where The Boilers Are: A Survey of Electric Utility Boilers With Potential Capacity For Burning Solid Waste As Fuel. U. S. Environmental Protection Agency Publication SW-88c, 1974.

13. Unlisted author, Environmental Science and Technology, "Liabilities Into Assets," Vol. 8, No. 3, p. 210.

14. U. S. Environmental Protection Agency, Salvage Markets For Materials In Solid Waste, U. S. Government Printing Office, Washington, D. C., 1972.

15. ______________________, Solid Waste Demonstration Projects, Publication SW-4, p. __, U. S. Government Printing Office, Washington, D. C., 1972.

16. Weddle, Bruce and Garland, George. "Dumps: A Potential Threat to Our Groundwater Supplies," Nation's Cities, October, 1974, p. 22, 24.